The Impact of Ionospheric Occultation Data on the Global Assimilative Ionosphere Model (GAIM)

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Abstract

As the number of ground and space-based receivers tracking the global positioning system (GPS) steadily increases, and the quantity of other ionospheric remote sensing data such as measurements of airglow also increases, it is becoming possible to monitor changes in the ionosphere continuously and on a global scale with unprecedented accuracy and reliability. However, in order to make effective use of such a large volume of data for both ionospheric specification and forecast, it is important to develop a data-driven ionospheric model that is consistent with the underlying physical principles governing ionosphere dynamics.

A fully 3-dimensional Global Assimilative Ionosphere Model (GAIM) is currently being developed by a joint University of Southern California and JPL team. GAIM uses a first-principles ionospheric physics model and Kalman filtering or a 4DVAR technique to not only solve for densities on a 3D grid but also estimate key driving forces which are inputs to the theoretical model, such as the ExB drift, neutral winds, and production terms. The driving forces are estimated by using the "adjoint equation" to compute the required partial derivatives, thereby greatly reducing the computational demands compared to other techniques such as finite differencing. For estimation of the grid densities, GAIM uses an approximate Kalman filter implementation in which the portions of the covariance matrix that are retained (the off-diagonal elements) are determined by assumed but physical correlation lengths in the ionosphere. By selecting how sparse or full the covariance matrix is over repeated Kalman filter runs, one can fully investigate the tradeoff between estimation accuracy and computational speed.

The effectiveness of ionospheric occultations for specifying the ionosphere is assessed by assimilating CHAMP, SAC-C and IOX occultations into GAIM and validating the electron density field against independent measurements. A series of such GAIM retrievals will be presented and validated by comparisons to: vertical TEC data from the TOPEX altimeter, slant TEC data from ground GPS sites, and a global network of ionosondes.